Therefore, using (4.15) and (4.16) the total pressure gradient (4.12) becomes

$$\boxed{\nabla_z p_T = g \nabla_s \zeta + \frac{g}{\rho_0}\left[\rho_{surface} \nabla_s \zeta + \int_s^0 \left(\frac{\partial z}{\partial s}\nabla_s \rho - \frac{\partial \rho}{\partial s}\nabla_s z\right) ds\right]} \qquad (4.17)$$

ⓔ <u>Pressure Gradient in (ξ, η, s, t) coordinates</u>

- Component in the ξ-direction

$$\boxed{\frac{H_z}{n}\left[\frac{\partial \phi}{\partial \xi} + g \frac{\partial \zeta}{\partial \xi}\right]} \qquad (4.18)$$

where

$$\boxed{\frac{\partial \phi}{\partial \xi} = \frac{g}{\rho_0}\left[\rho_{surface}\frac{\partial \zeta}{\partial \xi} + \int_s^0 \left(\frac{\partial z}{\partial s}\frac{\partial \rho}{\partial \xi} - \frac{\partial \rho}{\partial s}\frac{\partial z}{\partial \xi}\right) ds\right]} \qquad (4.19)$$

- Component in the η-direction

$$\boxed{\frac{H_z}{m}\left[\frac{\partial \phi}{\partial \eta} + g \frac{\partial \zeta}{\partial \eta}\right]} \qquad (4.20)$$

where

$$\boxed{\frac{\partial \phi}{\partial \eta} = \frac{g}{\rho_0}\left[\rho_{surface}\frac{\partial \zeta}{\partial \eta} + \int_s^0 \left(\frac{\partial z}{\partial s}\frac{\partial \rho}{\partial \eta} - \frac{\partial \rho}{\partial s}\frac{\partial z}{\partial \eta}\right) ds\right]} \qquad (4.21)$$